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SIGNAL SIMULATOR MODEL A-111

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16. Abstract

This report describes a signal simulator designed to function as a signal source for Doppler tracking high data rate receivers. The simulator produces modulated signals whose carrier frequency can be varied between 200 and 900 MHz at rates greater than 20 MHz/sec. The modulation is phase shift keying with data rate up to 300 megabits per second.

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PREFACE

This is the final report on Contract NAS-5-23211 titled Signal Simulator Model A-111. The project objective was the design and fabrication of a signal source to be used in the testing of a wideband Doppler tracking receiver backend, which was developed at AIL under Contract NAS-5-23183. The requirements of the test signal are that it have a carrier frequency variable between 200 and 900 MHz that is phase-shift-keyed modulated at a data rate of 300 megabits per second and with a power level adjustable between -20 and -80 dBm.

Tuning of the signal source is accomplished by both a manual control on its front panel and by an external control voltage applied to a connector also on its front panel.

The fabricated signal source provides a test signal in accordance with the stated requirements. It has been used as the signal source for tests of the wideband receiver backend during which near error free operation was noted at high signal-to-noise ratios.

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1.0 INTRODUCTION

This is the final report describing the Signal Simulator developed by AIL under Contract NAS-5-23211.

2.0 DESIGN OBJECTIVES

2.1 APPLICATION

The Signal Simulator has been designed to function as a signal source for Doppler tracking high data rate receivers. It will be used in a laboratory environment to evaluate the tracking ability and error rate of these receivers.

2.2 SIGNAL CHARACTERISTICS

The simulator is capable of producing signals with the following characteristics:

- Carrier frequency range of 200 to 900 MHz
- Carrier frequency variations of at least 20 MHz/s
- Modulation of amplitude modulated double-sideband suppressed carrier
- Data rate of at least 300 megabits/s (NRZ-L)
- Signal power output of at least -50 dBm
- System bit error rate of less than 1 bit in 10^6
- Dc power requirement of less than 20 watts

  -300 mA at +28 volts

  -300 mA at -36 volts

2.3 PHYSICAL CHARACTERISTICS

The simulator is a single rack mountable unit with a control panel. Its inputs are ac power, MECL III compatible binary data, and a control voltage to tune the unit's carrier frequency and to simulate the Doppler frequency.

3.0 SIMULATOR DESCRIPTION

3.1 BLOCK DIAGRAM

The signal simulator block diagram is shown on Figure 1. A 1.5-GHz cavity type oscillator provides a signal to the balanced modulator where the binary data is applied to

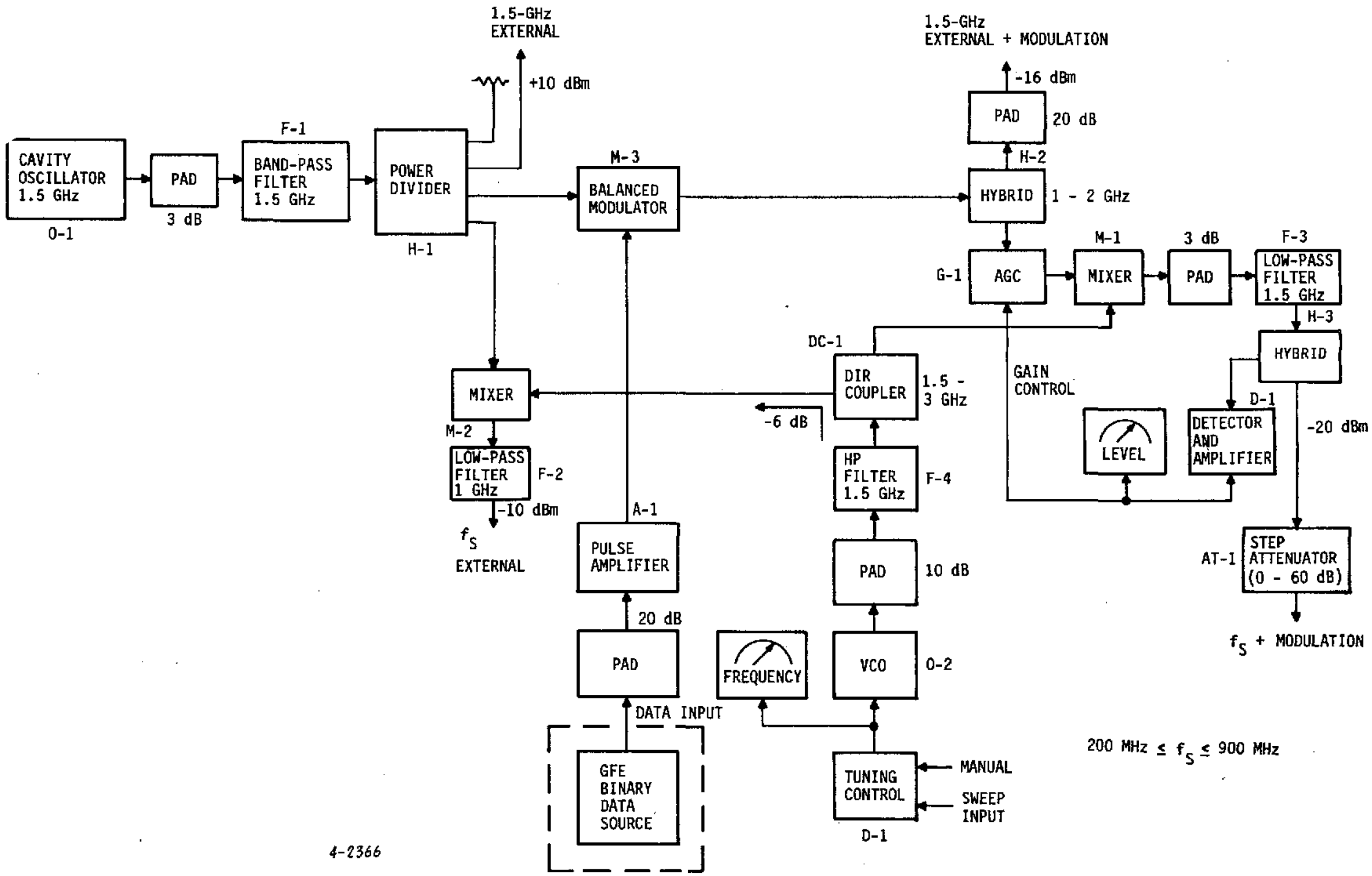


Figure 1. Signal Simulator Block Diagram

the modulator IF port. The modulator output signal is phase-dependent on the polarity of the binary data so that it consists of a sequence of carrier elements occurring at the data rate differing from each other by either zero or a nominal 180 degrees. This type signal is described as phase shift keyed or binary amplitude modulated-double sideband-suppressed carrier.

The modulator output is amplitude leveled and mixed with a voltage controlled oscillator signal whose frequency is between 1.7 and 2.4 GHz. The difference frequency output from the mixer is then a modulated signal between 200 and 900 MHz. The mixer output level is sensed to control the AGC leveling element and finally passed through a step attenuator to the signal simulator's output connector.

Also available for test purposes are samples of the 1.5-GHz source before and after modulation and an unmodulated sample at the signal frequency.

3.2 PRINCIPAL COMPONENTS

The principal components are:

- Cavity Oscillator--This oscillator has about a +20 dBm output at 1.5 GHz. (0-1)
- Balanced Modulator--This unit is a 1 to 2 GHz doubly balanced mixer. (M-3)
- AGC--This element is an absorptive modulator used to level the modulated signal output. (AGC)
- Mixer 1--This mixer is a wideband unit which converts the modulated 1500-MHz signal to the desired 200 to 900 MHz modulated output. (M-1)
- Step Attenuator--This device provides selectable attenuation (up to 60 dB) for the output signal in 10-dB steps. (AT-1)
- Pulse Amplifier and Pad--These components, with a 1.25 ns maximum rise time (20 percent droop with an 8-μs pulse) and up to 29 dB of gain, determine the binary data level applied to the modulator. (A-1)
- VCO--This oscillator tunes between 1.5 and 3.0 GHz with a nominal power output of +17 dBm and tuning sensitivity of 50 MHz per volt. (0-2)
- Tuning Control--This printed circuit board contains the circuits for leveling the simulator signal output power and it also conditions the tuning voltage for the VCO. (D-1)

3.3 CIRCUIT DIAGRAM

Figure 2 contains the circuit diagram for the simulator printed circuit board. U2 amplifies the sampled and detected simulator signal so that when it exceeds the threshold established by R20 and R21, the voltage from U3 and Q3 will control the AGC element maintaining the signal output at a constant level. Trimpot R3 adjusts the offset voltage from U2 so that it is zero with the detector disconnected.

U1, Q1, and Q2 amplify the tuning voltage from the front panel tuning potentiometer and from the external sweep connector (if the tune switch selects it) to provide the VCO tuning voltage.

3.4 MEASURED PERFORMANCE AND CALIBRATIONS

3.4.1 POWER REQUIREMENTS

The measured ac current required is about 0.5 A at 117 Vac.

3.4.2 SIGNAL OUTPUTS

The modulated RF power (f_s + MOD) into the six-step 60-dB front panel level control is nominally -20 dBm. Figure 3 shows its variation with frequency. In addition, test signals of 1.5 GHz, modulated and unmodulated, are available at the back panel at nominal powers of -16 and +10 dBm, respectively. Also, a front panel connector marked f_s provides a nominal -10 dBm signal at the (f_s + MOD) carrier frequency.

3.4.3 SIGNAL INPUTS

The signal simulator has two front panel signal input connectors labeled data and sweep. The data input has been padded so that 1-volt peak-to-peak pulses with widths from about 1 μs to 3 ns will fully phase-shift modulate the output signal with carrier suppression of about 22 dB. Different data input levels are accommodated by appropriately changing the data input attenuation.

The sweep input line is active only when the front panel tune switch is on "Ext." Voltages at this connector will then decrease the signal frequency from its manual setting by about 500 MHz for each volt the sweep input goes positive.

3.4.4 CALIBRATION

Figure 4 shows the signal output carrier frequency associated with the front panel meter reading when the meter switch is in the "Freq" position. This permits directly relating the carrier frequency with the meter reading when the external sweep is in use.

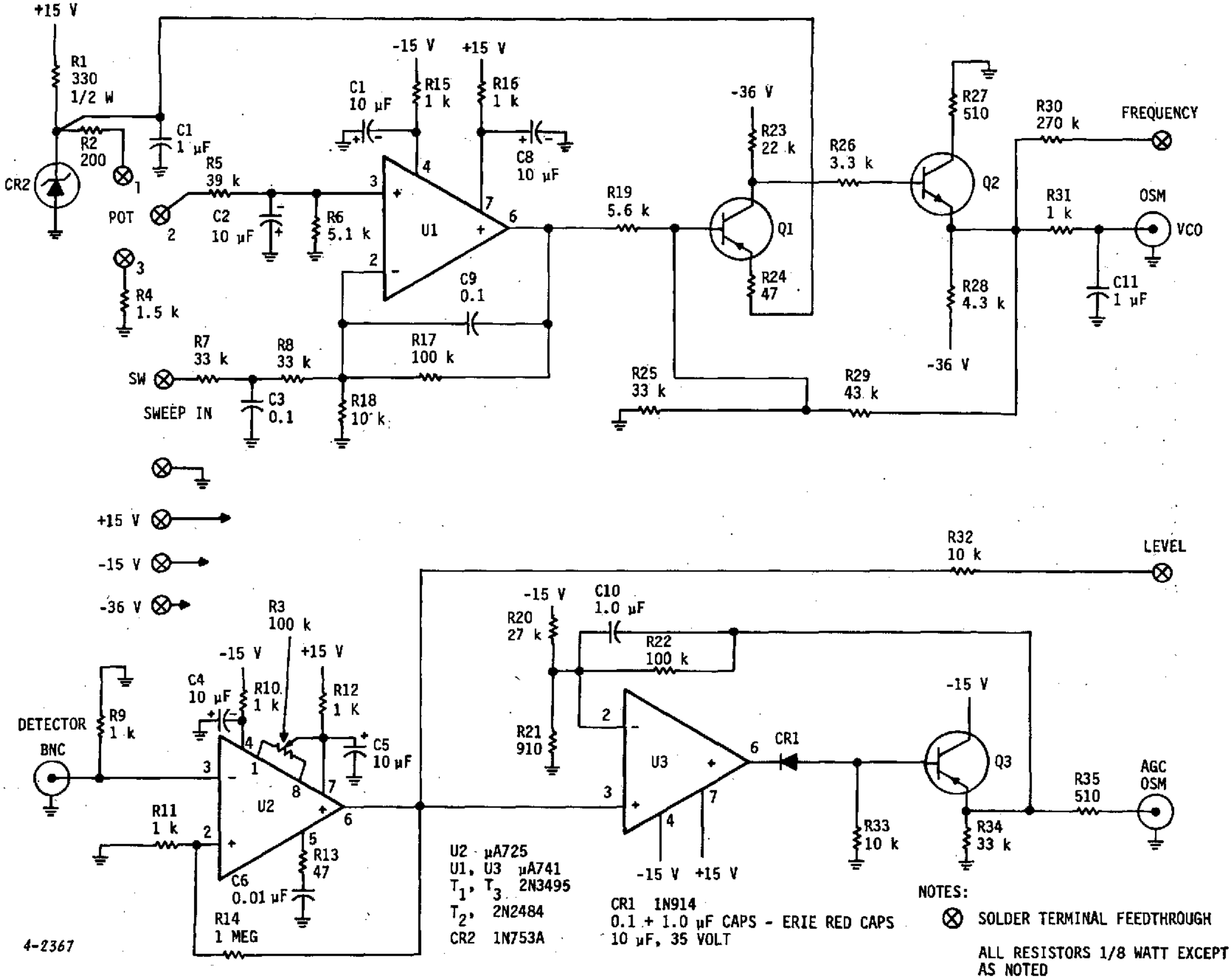


Figure 2. Simulator Circuit Schematic

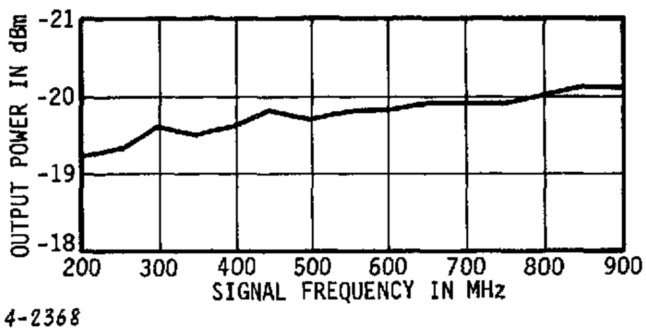


Figure 3. Signal Simulator Available Signal Power

The calibration of the front panel meter when the meter switch is in the level position is shown in Figure 5.

4.0 OPERATING INSTRUCTIONS

4.1 SIGNAL INPUTS AND OUTPUTS

The front panel contains four BNC connectors. Two provide signal inputs; the binary data input and the sweep voltage input. The other two front panel connectors provide outputs for the modulated signal, f_s + MOD, and the unmodulated signal, f_s.

There are also two BNC connectors on the rear of the chassis. These carry 1.5-GHz test signals with one being modulated by the data signal and the other unmodulated.

4.2 OPERATION AND CONTROLS

Operation of the simulator requires application of 105 to 125 Vac at 57 to 63 Hz for power and the appropriate signal inputs, binary data with data rate between 1 and 300 megabits per second, and the sweep voltage if desired.

The pads before the pulse amplifier (20 dB) have been selected to provide optimum modulation for a 1-volt peak-to-peak data signal.

The Manual Tune front panel control is a 10-turn potentiometer used to manually tune the VCO. The tuning voltage may be monitored on the front panel meter when the

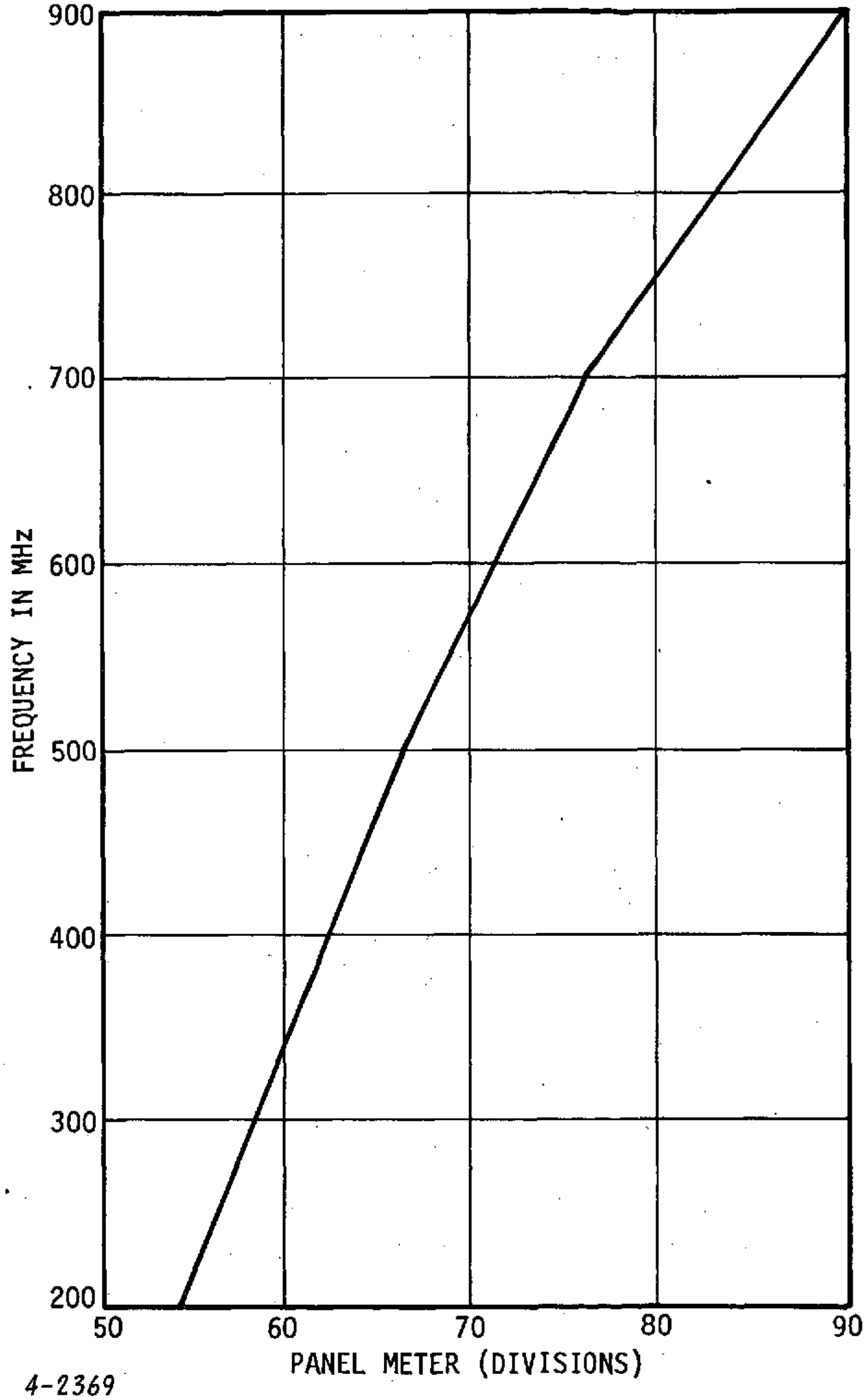


Figure 4. Signal Simulator Panel Meter Frequency Calibration

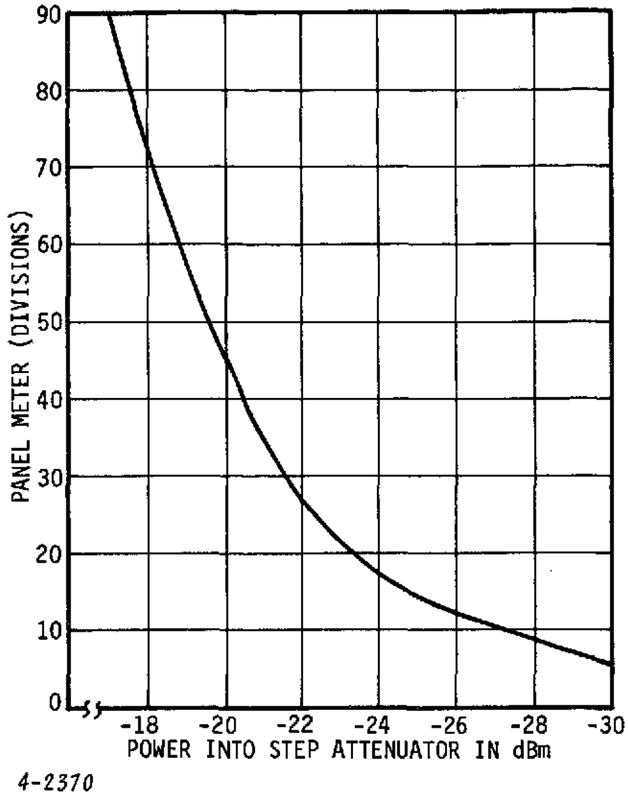


Figure 5. Signal Simulator Output Power Meter Calibration

meter switch is in the "Tune Volts" position. The external sweep voltage will be added to the manual control when the tune switch is in the "EXT SWP" position. The VCO tuning voltage sensitivity to the sweep input is nominally 9.5 V per volt.

The modulated signal output is available at the front panel f_s + MOD connector. Its level into the step attenuator may be monitored on the panel meter when the meter switch is in the "RF Level" position. The output RF level may be decreased in six 10-dB steps by the front panel "Level Set" control. The nominal modulated RF power to the attenuator is -20 dBm.

The signal carrier frequency may be monitored with a frequency counter connected to the front panel "f_s" connector.

5.0 MECHANICAL CONFIGURATION

Photographs of the Signal Simulator are contained in Figures 6 through 8. An assembly of the circuit board from the wiring side is shown in Figure 9. The Signal Simulator wiring diagram is in Figure 10.

6.0 MAINTENANCE

There are no special maintenance requirements for the Signal Simulator.

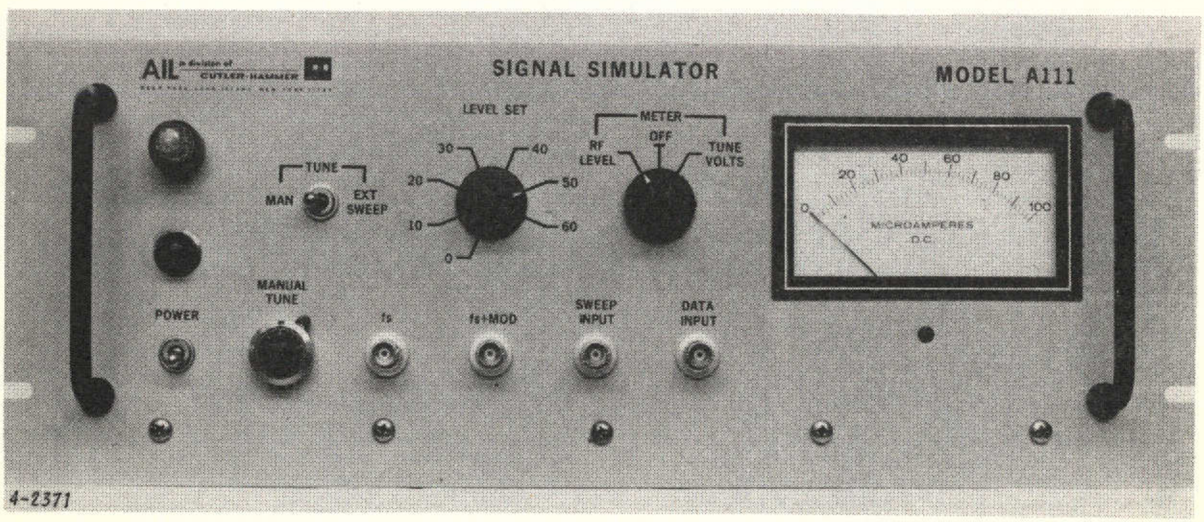


Figure 6. Signal Simulator Front Panel

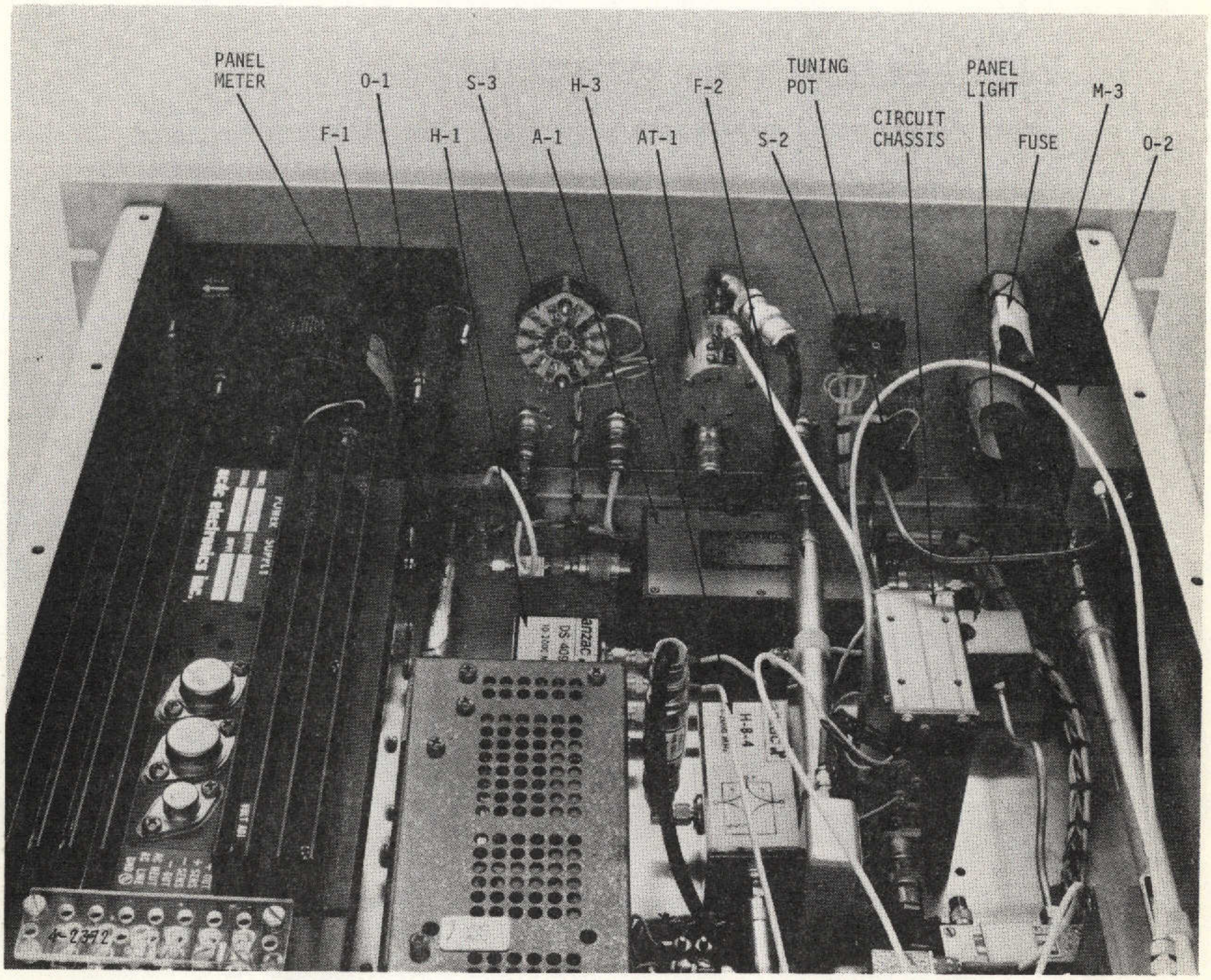


Figure 7. Chassis Assembly--Forward View

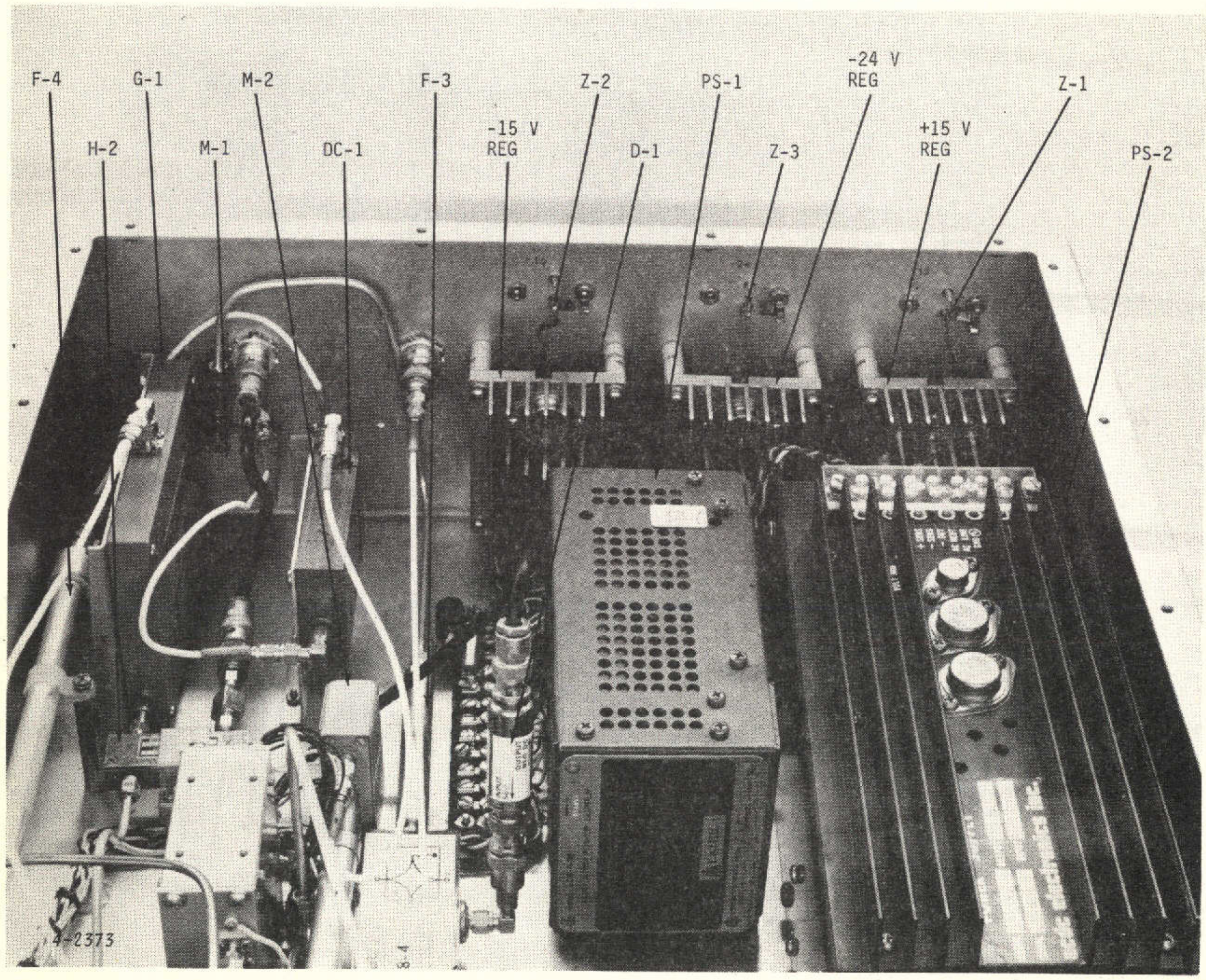
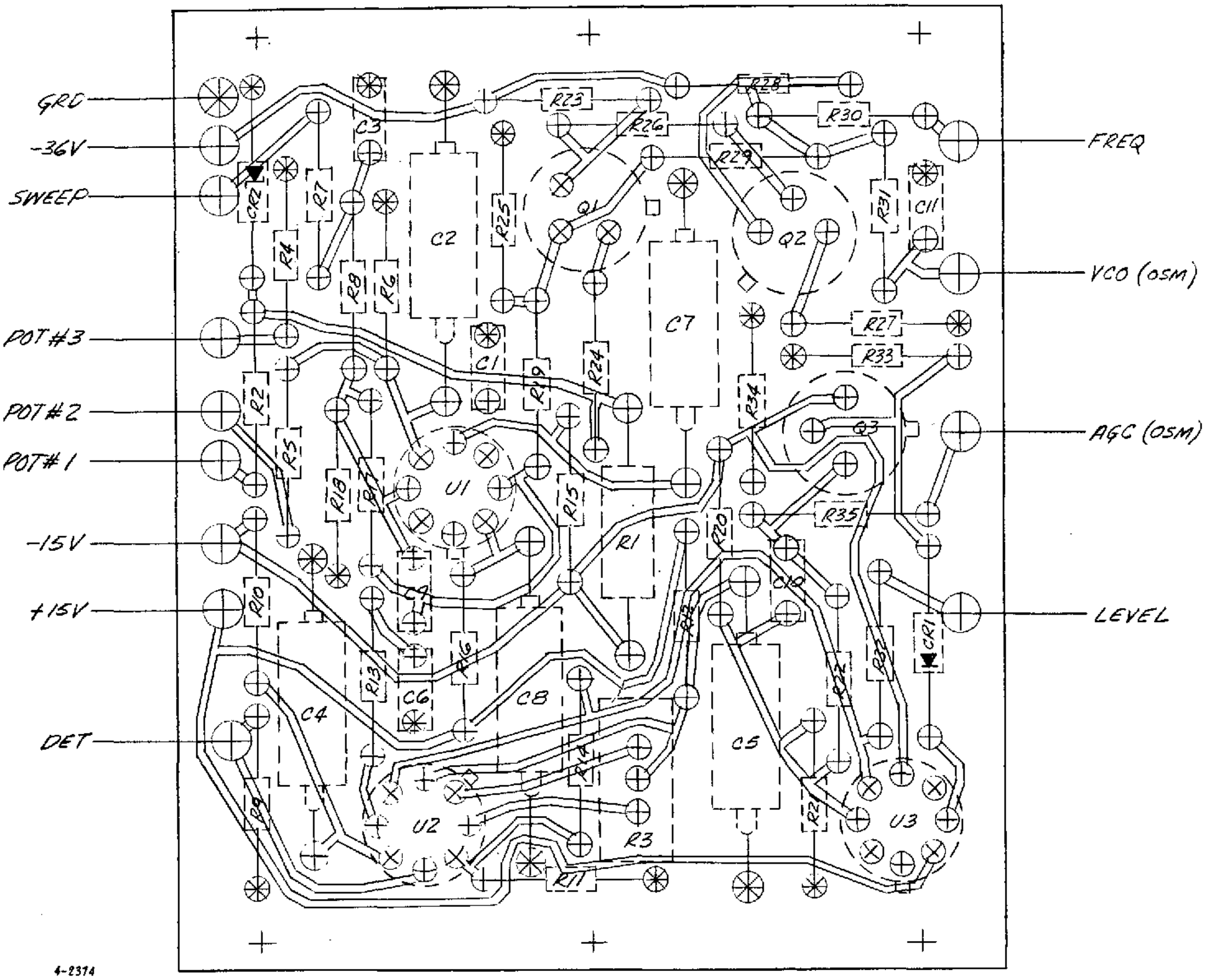


Figure 8. Chassis Assembly--Rear View



WIRING SIDE

Figure 9. Circuit Board Assembly

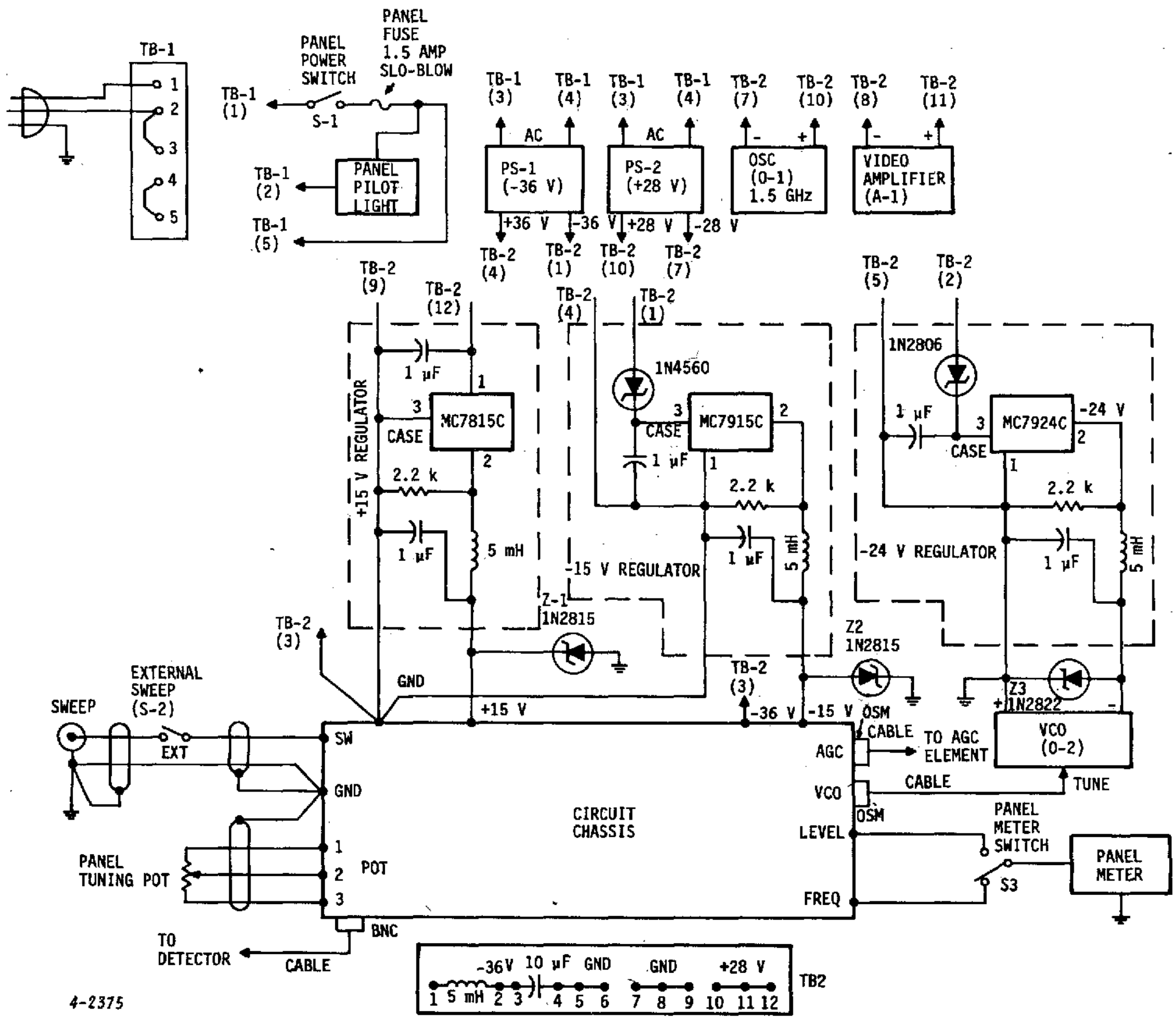


Figure 10. Wiring Diagram